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SHORT COMMUNICATION

Effect of seed mass on emergence and seedling development in *Pterocarpus marsupium* Roxb.

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Abstract: We investigated the effect of seed mass on emergence, seedling survival and growth of *Pterocarpus marsupium* Roxb., a medium to large, commercially valuable and deciduous tree species. Among the three size classes viz. small (10−12 mm), medium (13−15 mm) and large (16−17 mm), the maximum proportion of seed by number (54.12%) and dry weight (51.87%) was recorded in the medium size seed class. Seed length and seed width were greatest in the large seed class (16.50 mm, 7.33 mm) followed by medium (13.50 mm, 5.60 mm) and small (11.37 mm, 3.66 mm). Similarly, hundred seed weight (100 sw) varied from a maximum of 12.92 g in the large seed class to intermediate 10.95 g in the medium seed class and minimum of 7.02 g in the small seed class. The large seed size showed maximum emergence and shoot length over the medium and small seed class. After six months of growth, significant variations due to seed size were also observed for the growth and dry weight of *P. marsupium* seedlings. Seedling vigour, expressed in terms of height, collar diameter, number of leaves and dry biomass, was significantly affected by seed class. Seedlings that emerged from large seeds showed better growth and produced heavier seedlings as compared to medium and small seeds.

Key words: emergence, grading, *Pterocarpus marsupium,* seedling

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Introduction

The relationships between seed mass and seedling growth and performance have received considerable attention (Nagrajan and Mertia 2006; Singh and Saxena 2009). The difference in seed mass among species is due to different levels of starch and other food storage, and their influences on germination and seedling growth (Wood et al. 1977). Some workers (Khan and Shankar 2001; Arunachalam et al. 2003; Suresh et al. 2003) observed that germination rates and seedling growth were higher for larger seeds, while others (Wood et al. 1977) reported that small or medium seeds performed better than large seeds. In certain species, however, seed size might not affect germination rates (Cideciyan and Malloch 1982), seedling growth, or dry weight (Carelton and Cooper 1972). Although the effect of seed size on germination and seedling growth has been reported for a number of species (Upadhyaya et al. 2007; Singh and Saxena 2009; Sadeghi et al. 2011), *Pterocarpus marsupium* has not been studied. Our study aimed to analyse the seed size variation and its effect on the emergence of seedlings, early growth and dry weight accumulation in *P. marsupium*.

Pterocarpus marsupium (Indian Kino or Malabar Kino) is valued for excellent timber that ranks next to teak and rosewood in peninsular India. The Malabar Kino tree also yields gum kino, which is a powerful astringent, used for treatments of diarrhea, dysentery, leucorrhea, hemorrhages and toothache. Water stored in vessels made of kino wood is reputed to have antidiabetic properties possibly due to transfer of antidiabetic content into water (Seshachary 1983). The mature tree harvested after 10–15 years produces approximately 500 kg of dry heartwood. The native natural stands of this tree are fast disappearing due to illicit felling to meet demand for the multipurpose properties and high market price of its dry heartwood (Rs. 70/kg) (NMPB 2008), which in turn have led to its inclusion in the list of endangered plant species. *P. marsupium* is a deciduous and indegenous leguminous tree found in the Deccan Peninsula, central India and

certain parts of northern India. The seeds collected from Bastar Division, Chhattisgarh showed visible variation in pod and seed (Fig. 1 a, b). The objectives of the present study were to determine if seed weight affects germination rate and if seedlings derived from heavier seeds are more competitive and have high survival and vigour. This information is desired for developing methods for grading and selection of superior seed stock for large-scale plantation.

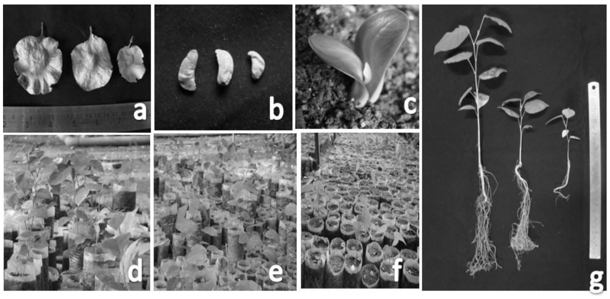

Fig. 1: Emergence and growth of *Pterocarpus marsupium* seedlings: (a & b) variation in pod and seed size; (c) emergence of seedlings from seeds; (d) seedlings raised from large (e) medium and (f) small size seed class; (g) variation in shoot and root length in seedlings raised from large, medium and small size seed class.

Materials and methods

The study was undertaken at Tropical Forest Research Institute, Jabalpur, India, at 20°17′45″ N latitude and 85°49′15″ E longitude. Of the total annual rainfall of 1500 mm, 75% is generally recorded between July and September. The mean temperature of the region varies from a maximum of 42– 44 °C in April–May to a minimum of 8–12 °C in December. Based on the climatic characteristics, the year is divisible into summer, rainy and winter seasons.

The pods of *P. marsupium* were collected in the month of May from 20 widely spaced, phenotypically strong, and disease free trees of almost similar ages from Tadoki beat of Antagarh range in Bastar Forest Division, Chhattisgarh. Approximately 450 pods (250 g each) were collected mostly from the periphery of the crown. Pods were dried in sun and the seeds were extracted manually from the pods with the help of a scalpel. Equal quantities (25 g) of seeds from 20 trees were mixed together to make the composite seed lot. Seed size variation was determined by taking 200 g sample from the seed lot and length of each seed was measured using a vernier-calliper. Seeds were then classified into small (10–12 mm), medium (13.15 mm) and large (16–17 mm) size classes according to their length. After size grading, the proportion of number and weight of the seed in each size class was recorded. Damaged seeds were discarded and only uniform and undamaged seeds were used for emergence tests. The 100 seed weight of each class was determined in three replications. Similarly, the average seed length and seed width in each size class out of 100 seeds were also recorded using a vernier-calliper.

In nursery condition, three replicates of 25 seeds each from different size classes were sown in polythene bags (30 × 45 cm), filled with sand: soil: farm yard manure (FYM) in equal quantities (ratio of 1:1:1) at 2 cm depth from the top and arranged in a Randomized Block Design (RBD). Seeds were not treated prior to planting. Watering was done once in three days to maintain soil moisture. Coming out of cotyledons just above the soil surface was considered as emergence (Fig. 1c). Counts of seedling emergence were made daily until the completion of emergence, i.e 60 days. Thereafter, the percent of seedling emergence and shoot length were counted. These parameters were calculated to test the vigour of different seed classes of *P. marsupium*. For estimation of growth and dry weight of seedlings, five randomly selected seedlings from each replication were harvested from the polybags and measured for their height, collar diameter and number of leaves six months after seeds were sown. Observations on dry root/shoot biomass for seeds of each size class were recorded after six months by destructive sampling. For quantification of dry root/shoot biomass, the samples were oven dried at 60 °C for four days.

Results

Seed size and weight

There was wide variation in seed size of *P. marsupium*. We grouped seeds into three size classes, *viz.* small (10–12 mm), medium (13–15 mm) and large (16–17 mm). Of the total seeds in a sample, the seeds of medium size were most numerous (54.12%), followed by small seeds (33.32%) (Table 1). Only 12.52% of all seeds were large. On the basis of weight, medium sized seeds accounted for 51.87% of the total sample weight, significantly more than small (21.96%) or large (23.07%) seeds. The physical characters of seeds were significantly different between the size classes. Greater seed length (16.50 mm) and width (7.33 mm) among large seeds corresponded to greater 100 seed weights (12.92 g) as compared to medium (10.95 g) and small seed size (7.02 g) (Table 1).

Table 1: Proportion and physical characteristics of seeds of *Pterocarpus marsupium* in different size classes

Seed size class	Proportion of seed		Seed length (mm)	Seed width (mm)	100-seed wt (g)
	By No. (%)	By wt. (%)			
Small (10–12 mm)	33.32	21.96	11.37	3.66	7.02
Medium (13–15 mm)	54.12	51.87	13.50	5.66	10.95
Large (16–17 mm)	12.52	23.07	16.50	7.33	12.92
CD (5%)	2.02	0.39	1.52	1.51	1.07
SEm±	0.51	0.14	0.54	0.54	0.38

Emergence behaviour

Seed size was an important factor to assess emergence rates and other related parameters in *P. marsupium*. Seeds of different size classes showed significantly different emergence behaviour in

natural conditions (Fig. 1 d, e, f). The highest emergence rate (76%) was recorded for large seeds and this was significantly greater than the rates for medium or small seeds (Table 2).

Table 2: Effect of seed size on emergence rates of seedlings of *Pterocarpus marsupium*

Seed size class	Emergence of seedlings %
Small	42.66
Medium	41.33
Large	76
CD (5%)	25.98
SEm±	9.36

Seedling growth and dry weight

Seedling growth and biomass varied with seed size (Table 3). Height of seedlings was greatest for large seeds (20.61 cm) and was significantly greater than for medium or small seeds (Fig. 1 g). Although collar diameter showed an increasing trend from large to small seed size, the differences in size class means were not significant. Numbers of leaves produced by individual seedlings grown from large seeds was about 50% greater than for medium sized seeds and 59% greater than for small seeds. The total dry root+shoot weight per seedling was greatest in seedlings raised from large seeds (6.55 g) and was 3.5 times and 11 times greater than for seedlings grown from medium sized seeds (1.88 g) or small seeds (0.59 g), respectively. Root:shoot ratios of seedlings ranged from 0.74–1.68 with the higher value recorded for medium sized seeds, which was followed by small seeds and then large seeds. Large seeds had the lowest root:shoot ratio (Table 3).

Table 3: Growth and biomass of six months old seedlings of *Pterocarpus marsupium* raised from seeds of three size classes

Seed size	Growth parameters			Dry biomass			
	Height (cm)	Collar diameter (mm)	Number of leaves	Root wt (g)	Shoot wt (g)	Total wt (g)	Root:shoot weight ratio
Small	10.28	2.99	3.32	0.32	0.26	0.59	1.23
Medium	14.22	2.27	3.99	1.18	0.70	1.88	1.68
Large	20.61	2.16	7.99	2.81	3.76	6.55	0.74
CD at 0.05	3.84	0.92	0.69	0.44	0.31	0.51	1.43
SEm±	1.38	0.33	0.24	0.16	0.13	0.18	0.51

Discussion

The success of any plantation program depends in part on the planting stock. Grading or scaling of seed on the basis of size is a useful practice for minimizing variation in seedlings grown in the nursery. A close relationship between seed size and/or weight and production of good quality planting materials has been documented for many tropical tree species (Gupta et al. 1983; Ponnammal et al. 1993; Singh et al. 1993; Kumar 2007; Sivasubramaniam and Selvarani 2012). In the present study, *P. marsupium* showed wide variation in seed sizes that we categorized into three classes. In bulk seed samples, the proportion of seeds was highest in the medium size class. Predominance of medium sized seeds was also reported for *Acacia nilotica*, *Albizia lebbek* and *Dalbergia sissoo* (Khera et al. 2004). The variation in seed size and weight within a sample may be due to genetic or environmental differences (Schmidt 2000), and this resulted in our study in varation of seedling size.

The present study showed that seed size and weight affected the emergence and other associated parameters in *P. marsupium*. Larger seeds emerged at higher rates than did smaller seeds in natural conditions. Khan and Shankar (2001) and Arunachalama et al. (2003) also reported that heavier seeds performed better in terms of germination and other related parameters in *Quercus semiserrata* and *Mesua ferra*. Our findings that emergence rates were higher for larger and heavier seeds than for smaller seeds concur with the results of other workers for *Hardwickia binata* (Ponnammal et al. 1993), *Pongamia pinnata* (Arjunan et al. 1994), *A. catechu*, *A. nilotica* (Khera et al. 2004), *Prunus jenkinsii* (Upadhaya et al. 2007) and for *Alangium lamarckii* (Ahirwar 2012). This may be attributed to the larger food reserves and greater nutrient pool present in the endosperm of the heavier seeds (Tripathi and Khan 1990; Khan and Shankar 2001). However, contradictory results have also been reported for many species in which lighter seeds germinated and emerged earlier than heavier seeds (Marshall 1986; Murali 1997; Khan et al. 1999) due to the thick coat of the heavier seeds, which might have caused late emergence.

Seed size and weight in the present study showed a significant positive correlation with seedling growth and dry weight. This might be because the larger embryo with a greater reserve of nutritional matter enabled seedlings from large seeds to grow faster and accumulate greater dry weights than seedlings from small seeds (Ponnuswamy et al. 1991). Greater nutrient and energy reserves in heavy seeds might account for the better pre-photosynthetic growth of the seedlings (Tripathi and Khan 1990), which, in turn, might contribute to better growth and survival of seedlings. Greater plant growth and dry weight of seedlings from large and heavy seeds is in accordance with the findings for *Bassia longifolia* (Suresh et al. 2003), *Acacia nilotica* and *Albizia lebbek* (Khera et al. 2004), *Colophospermum mopane* (Nagarajan and Mertia 2006) and for *Prunus jenkinsii* (Upadhaya et al. 2007). The root:shoot ratio is used to assess the overall health of plants and increases in this ratio can indicate greater plant health. The highest root:shoot ratio obtained in the medium size seed class in the present study was within the range of the results of Singh and Saxena (2009) for *Jatropha curcas* seedlings. In the present study the lowest root:shoot ratio was recorded for the large seed class. However, the root:shoot growth response of any species is regulated genetically and by local environmental conditions (Enquist and Niklas 2002).

Conclusion

Small and medium sized seeds had low percentages of emergence and the seedlings raised from these seeds produced small

growth features and low dry weights. Bonfil (1998) and Long and Jones (1996) reported a positive correlation between seed mass and seedling survival and growth in *Quercus rugosa*, *Q.laurina* and 14 oak species, respectively, and our results support their conclusions. However, genetic factors may contribute to some variations in seedling growth and characteristics, i.e, height, diameter and root dry weights (Carles et al. 2009). This indicates that sufficient energy content of large seeds helps in producing better planting stock compared to medium sized and/or small seeds). This can be viewed as an important reproductive strategy, which describes the resource allocation particularly associated with reproduction through seeds of different sizes (Harper and Ogden 1970; Muoghalu and Chuba 2005). We recommend use of large seeds for better emergence and faster growth of seedlings of *P. marsupium*. The larger seedlings should be preferred for plantation programs because of their higher survival and growth rates in plantations as reported by Singh and Saxena (2009) for *Jatropha curcas*.

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